SRELS Journal of Information Management
Vol. 50, No. 4, August 2013, Paper AJ. p387-412.

IMPACT OF GRANT-IN-AID PROJECTS AT CSIR-NATIONAL METALLURGICAL LABORATORY, INDIA: A BIBLIOMETRIC STUDY

P.N. Mishra[1;] ***N.G. Goswami***[2] and ***K.C. Panda***[3]

The purpose of this study is to evaluate the impact of 204 Grant-in-Aid projects carried out at CSIR-National Metallurgical Laboratory, India during 1995-2010 through Bibliometric method. Unearths the impact of projects in the light of current needs to sustain in future. The data pertaining to study were generated through structured questionnaire. The output-identified as deliverables of each project includes, cash flow, process developed, patents, copyright, and technology transferred, academic contribution and research papers published through projects .The quality of papers were traced out through citation and impact factor. The Projects have been classified at different level of research- basic research, applied research, industrial research. The data further presented according to the level of research to accommodate 204 projects. The duration of the projects ranged from 6 months to 5 years. A group of 27 subject areas have been identified for all the projects, fall in the domain of Metallurgy and Materials Sciences and allied subjects .The value of projects were estimated around 55 Crore Rupees. About 97% projects were accomplished in scheduled time. The R&D output reflects that 55 processes were developed and only one technology could be transferred. However 21 technologies are under negotiation for transfer to different parties. During the tennure of projects, 40 patents and 14 copyrights were filed. About 58 students from various reputed academic institutions were benefited through projects. A total of 608 research papers were reported based on projects findings. The trends of publications during 16 years show that SCI papers are in increasing trends and reflects a healthy sign as performance indicators of the sponsored projects. The projects under basic research contributed a maximum of 226 papers with 845 citations, shared 64.50% of the total 1310 citations. The average impact factor of papers was 1.552. The highly cited papers published in the area of water quality-assessment, received 88 Citations, other highly cited papers fall in the domain of corrosion protection and prevention, waste management and utilization and materials science and technology. The output of the present work will be useful for scientists and decision makers to judge the impact of Grant- in-Aid projects in the light of current global scenario and making project selection mechanism more effective by tailoring to the current needs of the society.

KEYWORDS/DESCRIPTORS: Grant-in-Aid projects, R&D evaluation, CSIR-National Metallurgical Laboratory, Bibliometrics, Metallurgy and Materials Science, Public goods, Citation analysis, Impact factor, Productmetric study

1 INTRODUCTION

CSIR- National Metallurgical Laboratory, Jamshedpur, India is a premier R&D organization functioning under the aegis of Council of Scientific and Industrial Research. Late Pandit

[1] *Senior Scientist*, CSIR-National Metallurgical Laboratory, IMD Centre, PO. Burmamines, Jamshedpur 831007, Jharkhand, INDIA. E-Mail: pnmishra65@gmail.com

[2] *Chief Scientist*, CSIR-National Metallurgical Laboratory, IMD Centre, PO. Burmamines, Jamshedpur 831007, Jharkhand, INDIA.

[3] *Former Professor and Head*, Dept. of Library and Information Science, Sambalpur University, 'Panda Cottage', Gandhinagar 3rd Line Extn.Berhampur 760001 (Ganjam), Odisha, INDIA, E-mail: krushna52@yahoo.co.in

Jawaharlal Lal Nehru, the first Prime Minister and the architect of modern India founded it and inaugurated on 26th November 1950. The CSIR-NML, celebrated its Diamond Jubilee in 2010. This premier institution focuses primarily on the research and development on innovation, basic research, applied research and technology development, transfer and providing specialized services such as consultancy, standards reference materials, and quality support for scientific and industrial growth in the areas of minerals, metals, metallurgy, and materials respectively of high order.

The Laboratory has successfully carried out a number of projects assigned by industries, government bodies, academia, and private sectors at National as well as International levels. Depending upon the nature of assignment, the projects have been classified like, Sponsored research, Grant in Aid Project, Collaborative research (Bilateral & multilateral), Exploratory projects, etc.

Recently, the laboratory has accomplished two prestigious networks projects in the area of Materials Science and Technology, viz, Technology for Engineering Critical Assessment (TECA) and Technology for Assessment and Refurbishment of Engineering Materials and Components (TAREMaC) with investment of more than 30 million rupees each.

These projects were related to components integrity, evaluation, and characterizations used in strategic sectors like- power industries, railway, petrochemical, and defence.Currently, 190 projects of different categories are ongoing at NML [1]. The output of R&D projects tested through bibliometric methods might be the most useful method in determining the objectivity of projects in the present global scenario. Bibliometric analysis is being used very frequently for evaluating R&D activities. Its impact implies on institutions both at the level of individual scientists as well as on mapping of growth of scientific disciplines and the performance of laboratories. These studies initiating linear ranking lists, which have now been evolved into multidimensional indicators using new powerful data processing tools [2].

2 LITERATURE REVIEW

R&D evaluation is defined as a means to supply necessary information before carrying out R&D projects in order to purge uncertainty in R&D activities and procedures to analyze the information in the R&D outputs for effective decision-making. Until now, the purposes of R&D evaluation were limited to the internal utilization of the results. Such evaluation helps in guiding future action, involving both business and research decision to avoid or reduce wasted efforts and keep research people on their toes, assuring them of management interest in their activities. However, recently the focus of R&D evaluation has changed from in-house efficiency of R&D activities and internal utilization of R&D results to the impacts of R&D in the technical, social, and economic fields as reflected in the different studies viz. [3-7]. Therefore, the authors in this study intend to define R&D evaluation as case study to review the R&D outputs of Grant-in-aid projects for the last 16 years to draw its impact in the technical, social, and economic fields concerned with minerals, metals, metallurgy, and materials science respectively.

The earlier work focused on process evaluation, and *ex post* evaluation based on the evaluation timing; [6, 8]. As results of policy implementation, it may be into short- and long-term policy impacts [9], so the results of R&D can be divided into short-term R&D outputs and long-term impacts of R&D over the societal system. Hence, *ex post* R&D evaluation can broadly be reclassified into (i) output evaluation, and (ii) impact evaluation.

The output evaluation of present work has been planned to include three broad components, like general queries about projects, year wise distribution of projects, revenues generated, project assignee and R&D subject area. Technological output provides a number of deliverables like, technology-developed, patents, copyright filed, and publication output measured with citation analysis and impact factor of journals including top 15 highly cited papers are the other major parameters considered for the evaluation of Grant-in-Aid projects.

Measuring research and development (R&D) performance has become a fundamental concern for R&D managers and executives in the last decades. As a result, the issue has been extensively debated in innovation and R&D management literature. Jiancheng Guan, Nan MA [10] studied on Structural equation model with PLS path modeling for an integrated system of publicly funded basic research. Wayne and Barsky (1994) [11] in their study proposed an integrated performance measurement system that captures financial and non-financial performance by utilizing the balanced score card to present a framework to show how firms can link resource commitments to these activities and the firm's strategic objectives. Randle (1997) [12], on the other hand, proposed and used "interview technique" for measuring performance of UK- based pharmaceutical company-the Pharmex. The output of work is consisted of fifty semi-structured interviews, averaging around one hour in length, carried out between early 1993-1995.

Research and development (R&D) effectiveness has traditionally been measured in quantitative terms using measures such as the number of published papers (in journals, conference proceedings, etc.); patents; technologies successfully transferred or the external cash flow secured by a R&D organization. These are at times coupled with qualitative indicators such as the impact factor of the journals in which the papers are published and science citation index. However, all these measures often fail to adequately evaluate the effectiveness of research units that carry out technological innovation projects. The complexity of performance measurement problems in R&D organizations has resulted in a scarcity of generally accepted techniques.

Traditional performance measures are generally not appropriate because the nature of output of such an organization is often long-term and intangible. Literature on measurement of effectiveness of organizations (including academic and R&D organizations) has emphasized multi-dimensional measures of performance since no single measure can capture all the traits. [3 & 13-21] all have discussed the use of different scientometric methods for assessing the performance of different research institutes.

There are a number of studies in the literature evaluating R&D project performance and have introduced a framework for R&D project ranking, which integrates elements of previously published R&D projects ranking systems [22-34].

Stahs and Steger (1977) [35] on the other hand suggested two categories of innovation measures to capture the various measures of innovation. The *first* includes so-called objective measures and the *second* category the so-called subjective measures .Frequently used objective measures of innovation include counts of the number of publications or number of patents, etc. as reflected in the studies conducted by May (1997); Braun & Schubert (2003); Daigle & Arnold (2000); Guan and Ying (2005) [36-39]. Two major problems rose with the use of such measures. *First*, numbers of publications, patents, and patents applications seemed to be largely a function of organizational policy and security considerations. *Second*, there seemed to be an implicit assumption in the use of objective measures that the innovativeness of all publications was equal or likewise with all patents, etc. Perhaps, a weighted measure of numbers of publications, a patent, etc. may be considered appropriate. However, weighting usually implies a subjective evaluation. The innovation measures for present study focus on to help organizational policy.

Brown and Svenson (1992) in their work on, "Measuring R&D Productivity" suggested several typical outputs measured to include the number of research proposals written, papers published, products designed**,** presentations made, books written, patent received, awards won, projects completed, etc) [40].In the literature, the authors noticed a variety of suggestions for the measurement of R&D in different stages or for different purposes, or for different kinds of evaluation methods to use certain types of R&D output. The emphasis of different factors set different requirements for the evaluation criteria in the final selection of R&D performance measures [41]. The reviewed paper provides multiple dimensions of choice for evaluation of R&D projects, being inspired by earlier studies. An attempt has therefore been made in this study to measure impact of Grant-in- Aid projects for CSIR-National Metallurgical Laboratory, India, Jamshedpur (Jharkhand-Erstwhile Bihar) (*See* Fig.1).

3 METHODOLOGY

To measure effectiveness of Grant-in-Aid Projects at National Metallurgical Laboratory during 1995-2010, data were collected through a structured questionnaire and from sources like, NML in-house project database, Annual Reports (1995-2010), Project Reports, On-line databases like, Science Citation Index, and Metal Abstracts. To judge the quality and quantity of research papers, Impact Factor Lists-2009 have been incorporated in this study, where as citation data were collected through SCI database. The selected data were further classified, categorized, designed, analyzed, and computed for deriving interpretation to achieve the preordained objectives of the study.

4 OBJECTIVES

The effectiveness of any R&D project must be periodically evaluated so as to satisfy its funding and its utilitarian value. It helps in determining its worth in the context of its potential for further R&D program through sponsored project assigned by various agencies like Government, R&D Sectors, and Industries under Public Sector, Private Sector, Academic Institutions, Non Governmental Organizations (NGO) and so on. This study has been initiated to unmask various facts, which will help the decision makers for taking further required action. The output of this study hopefully would help the competent authorities to evaluate R&D projects, includes the following key objectives.

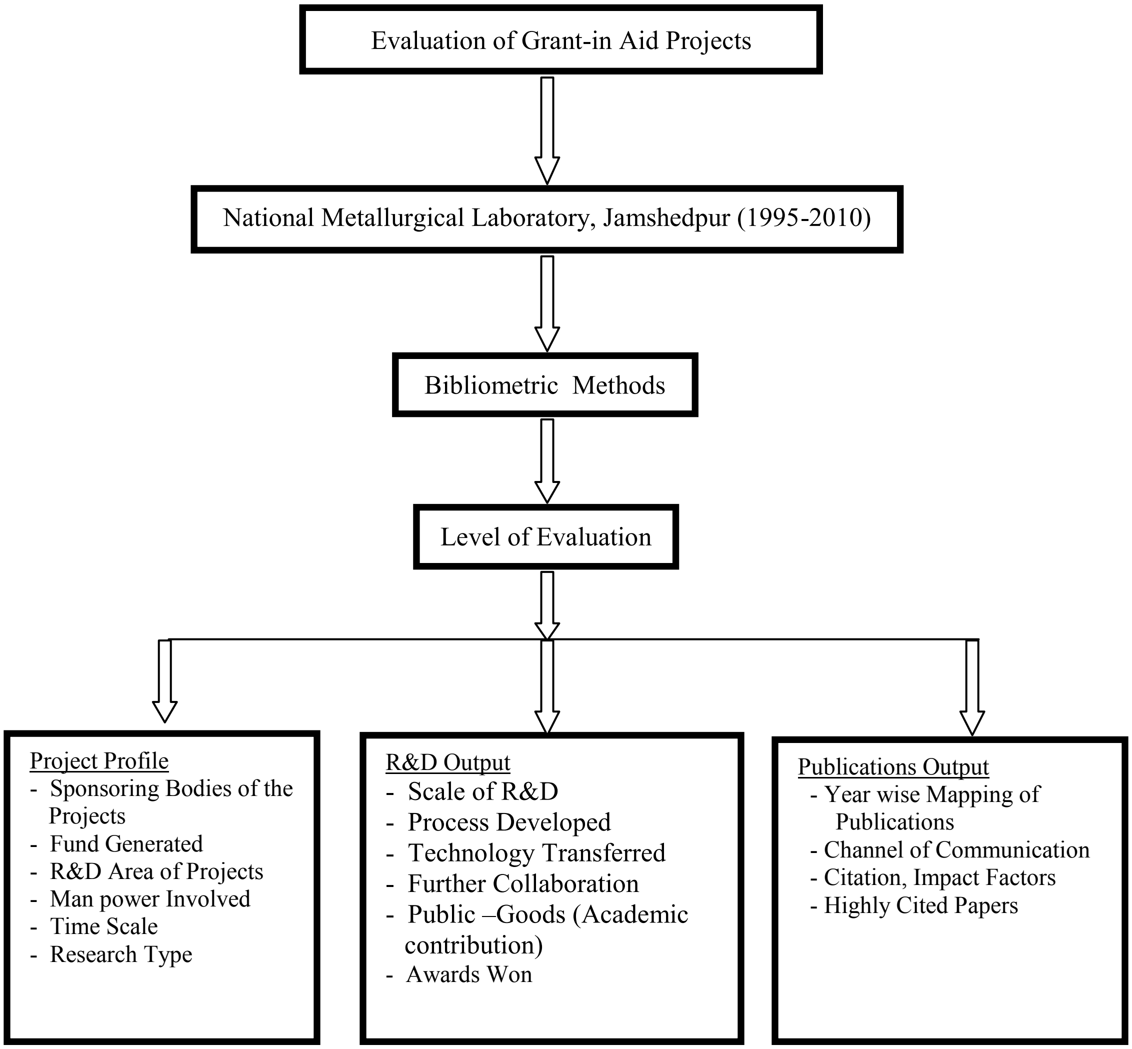

Fig.1: Diagrammatic view of model developed for projects analysis

- Year wise Growth of GAP;
- Cash flow through projects;
- Time Scale of projects;
- R&D Area wise distribution of projects;
- Distribution of sponsoring bodies;
- Work force participation in project;
- R&D output;

- Technology reported; if any
- Collaboration for further R&D project;
- Academic contribution (public goods);
- Awards/Honors won through projects;
- Publications Output;
- Year wise distribution of publications during 1995-2010;
- Quality of Research (Citation & Impact factor); and
- Top fifteen Highly Cited Papers.

5 RESULT AND DISCUSSION

The present study evaluates 204 Grant- in Aid Projects spanning over 16 years. Keeping in view of the objectives, the data were designed and charts prepared in a way, which would give important information for evaluation of GAP.

5.1 Year-wise Growth of Projects

During 1995-2010, 204 Grant-in-Aid projects were received at CSIR-National Metallurgical Laboratory, Jamshedpur. Figures 2 highlights, year wise distribution of projects. A maximum of 22 projects (11.22%) have been received in 2003, helped the laboratory to generate Rupees 946.96 lakhs**,** followed by the year 2007 which bagged 21 projects (10.20%) and earned Rupees 897.69 Lakhs and placed in second rank**.** The year 2006 has been placed in third rank for receiving 18 projects (8%) of the total 204 projects with a total value of Rupees 198.21 Lakhs. However, during 2008 only 16 projects (7%) were undertaken, but registered as the maximum revenue-generating year and earned Rupees 1140.70 Lakhs for the laboratory. Distribution of GAP depicted in Fig. 2, highlights the number of projects in four-block years showing an uneven distribution for last 16 years.

5.2 ECF Generated through GAP

During 1995-2010, a total of Rupees 5549.65726 (Rupees fifty-five crores, forty-nine lakhs sixty five thousand seven hundred twenty-six only) were earned through a total 204 Grants-in-Aid Projects sponsored by various agencies. The external cash-flow graph plotted for determining the trends reflects, three asymmetrical curves highlighting uneven distribution of cash flow. The curves further show peak point during 2007-2008; indicating maximum revenue generation in that period. Another peak point observed during 2001-2004, reflects less than the earlier one. The overall trends for external cash flow can be observed in Fig. 3.

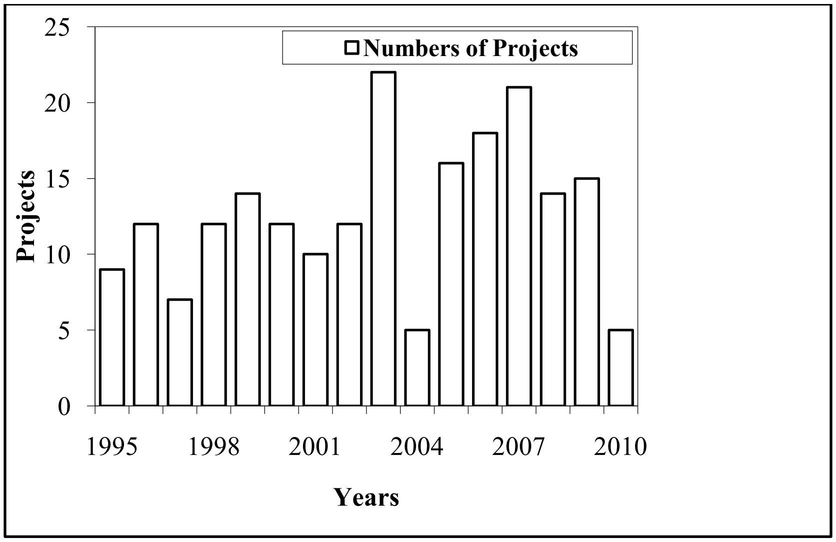

Fig. 2: Year-wise distribution of GAP during 1995-2010

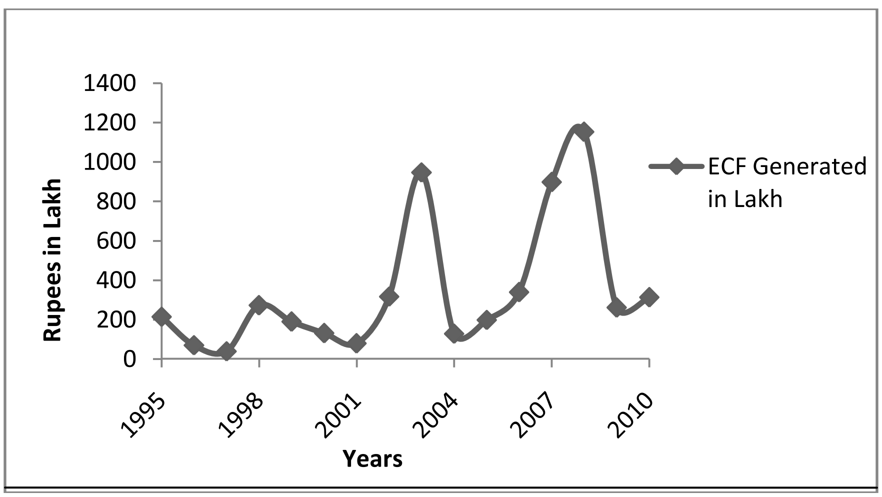

Fig. 3: Trends of ECF under GAP during 1995-2010

5.3 Time scale of Grant-in-Aid Project

Completion of any type of projects as per schedule is mandatory for an organization/ institution involved in handling sponsored projects. The project assignee also expects their output in proper time. The effectivity of projects has been evaluated to determine the timeliness of projects. The resultant data revealed that, up to 87 projects (42%) were of 2-3 years, followed by 44 projects (21%) expected to complete within 3-4 years and 36 projects are of range of 1-2 years respectively. Fig. 4 depicts the overall distribution of projects according to time scale. It was observed during the study that in all six slots of the time scale, only 6 projects (2.94%) had not been completed as per schedule which is quite insignificant, whereas 198 projects (97.04%) were completed within the time frame fixed by the projects assignees which is quite significant. The reason for delay was probably due to urgent foreign tours of project leaders, delay in supply of equipment and some projects required more time due to switch over to a different route to get findings in a way that was more precise. Most of the projects were completed as per the guideline laid down by the project assignees.

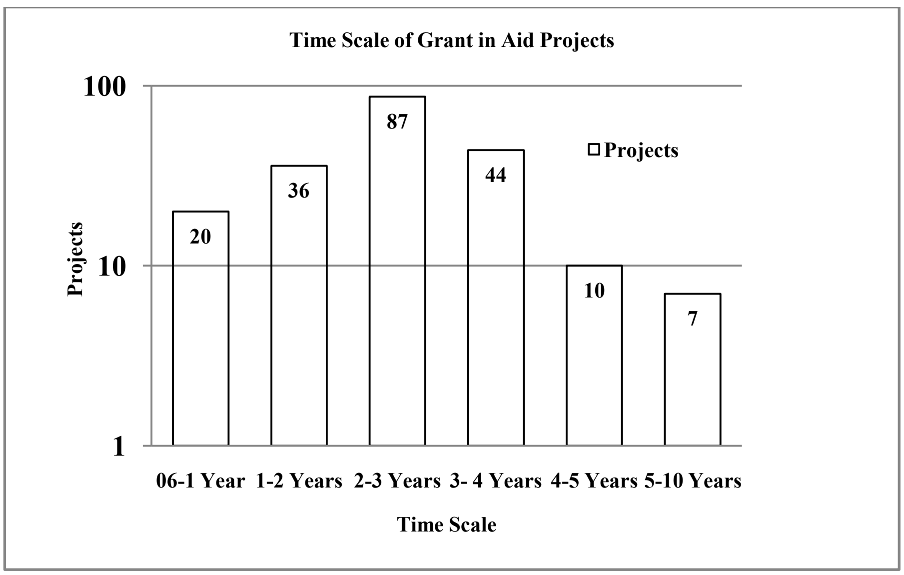

Fig. 4: Duration of Projects

5.4 R&D Areas of Projects

The broad subjects of the projects primarily fall in the domain of Metallurgy and Materials Science. Metallurgy deals with science and technology of metals and alloys. It consists of various narrow field of knowledge like *Process metallurgy* - concerned with the extraction of metals from their ores and with refining of metals; *Physical metallurgy* dealing with the physical and mechanical properties of metals as affected by composition, processing, and environmental conditions; and *Mechanical metallurgy* dealing with the response of metals to applied forces; while materials science includes those parts of Chemistry and Physics that deal with the properties of materials. Materials science encompasses four key classes of materials, the study of each of which may be considered a separate field like, Metals, Ceramics, Polymers, and Composites.

Materials science is often referred to as materials science and engineering because it has wider applications - Industrial applications of materials science include processing techniques (casting, rolling, welding, ion implantation, crystal growth, thin film deposition, sintering, and glass blowing etc.; include system besides, analytical techniques (electron microscopy, X-ray diffraction, calorimmetry, etc), materials design, and cost/benefit trade-offs in industrial production of materials [42].The Grant-in Aid projects were broadly related to minerals, metals, metallurgy, and materials science. A total of 190 projects fall in this area, followed by 10 projects pertaining to science and technology management and training, while two each of projects were related to infrastructural development and documentation of archieo- metallurgical study (Fig. 5).

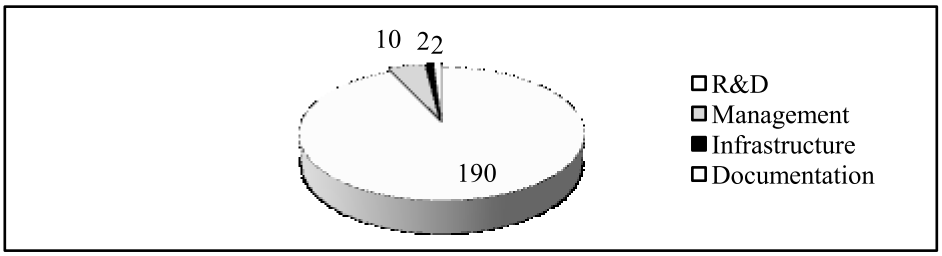

Fig. 5: Distribution GAP R&D areas

5.4.1 R&D Subject Areas of Projects

R&D projects have been broadly classified into 27 subject areas, ranging from minerals benefaction and characterization of indigenous ores such as iron ores, apatite, etc. to extraction of imported metals like copper, nickel, and cobalt from poly-metallic sea nodules of Indian Ocean (Arabian Sea).

To check environmental pollution from waste, a good number of projects were related to waste management and its utilization like extraction of metals from electronic wastes and effluent from industrial waste. To increase the iron productivity, some projects are related to blast furnace modeling and simulation.

Under Materials Science and Technology, a maximum number of 44 projects were executed under the subject ambience of materials characterization, evaluation and testing which constituted 21.56% of the total 204 projects; followed by 27 projects related to alloys development like magnesium, copper and iron and their commercial development for automotive applications and rural sectors. The contribution of these areas share 13.23%, where as the projects on steels related R&D area retained third rank with 15 projects constituting 7.35% of the total. The distribution of R&D area are shown in figures 6&7. The occurrence of 27-subject areas highlights NML core R&D area.

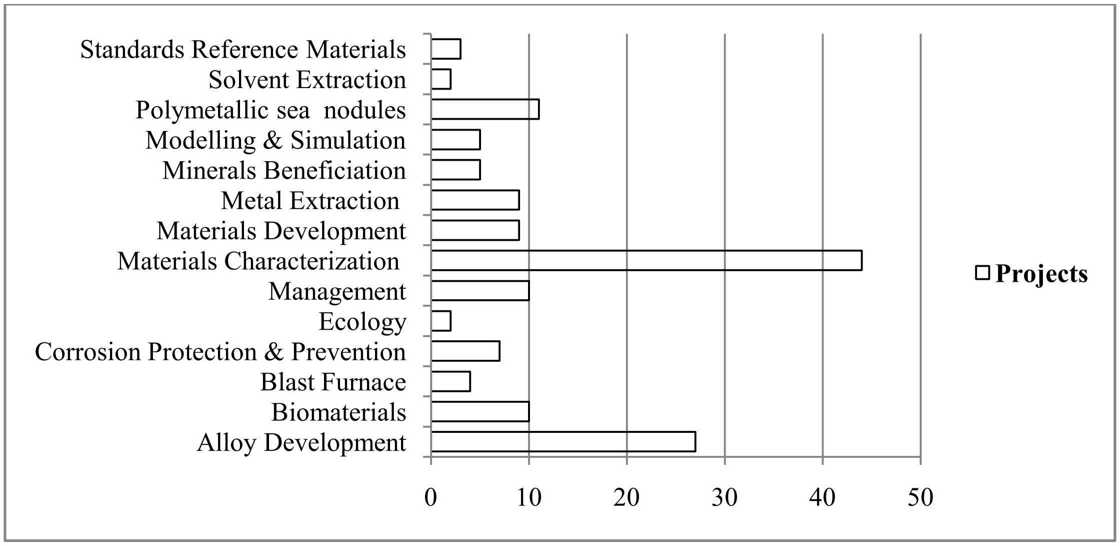

Fig.6: R&D area of projects

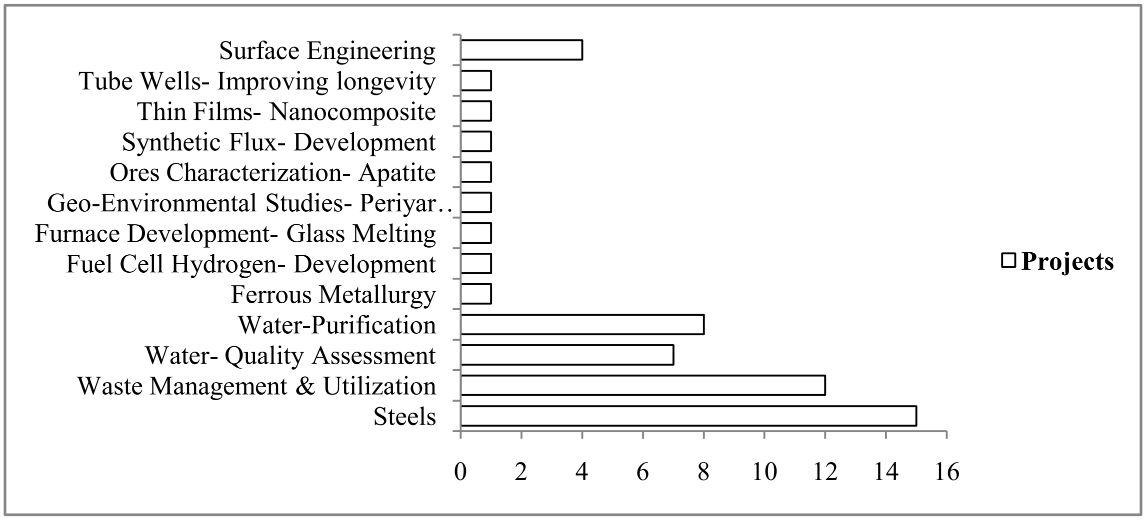

Fig.7: R&D area of projects

5.5 Sponsoring Bodies of Projects

The Grant-in-Aid Projects were assigned by different agencies – Government, R&D sectors, Public Sector, Private Sectors, Academia, NGO from India and abroad. A maximum 111 projects resulting in 54.41% of GAP assignee was from the Department of Science and Technology, Government of India, followed by Ministry of Defence which assigned 15 projects that constitute 7.35%, of the total projects, where as different laboratories under the umbrella of Council of Scientific and Industrial Research assigned 13 projects. Other project assignees are listed in Table 1. Some projects were of collaborative in nature like, Indo-US, Indo-Bulgaria and few projects were assigned by South Korea.

Table 1: Distribution of projects by sponsoring bodies

Sl. No.	Projects Assignee	Number of Projects	%	Cumulative
1	Department of Science & Technology, Govt of India	111	54.41	111
2	Ministry of Defence, Govt of India	15	7.35	126
3	Council of Scientific & Industrial Research, New Delhi	13	6.37	139
4	Academic Institutions, IIT, BHU, NIT, Local Engineering College	8	3.92	147
5	Public Sector Enterprises/Private	7	3.43	154
6	Ministry of Steel, Govt of India	7	3.43	161
7	Indo-US Projects	7	3.43	168
8	Dept of Ocean Development, Govt of India	6	2.94	174
9	Department of Atomic Energy, Govt of India	5	2.45	179
10	Ministry of Earth Sciences, Govt of India	4	1.96	183
11	KIGAM, South Korea	4	1.96	187
12	Ministry of Rural Development, Govt of India	3	1.47	190
13	Government of Jharkhand	3	1.47	193
14	Ministry of Coal & Mines, Govt of India	2	0.98	195
15	Ministry of Environment, Govt of India	2	0.98	197
16	Indian Space Research Organization, Govt of India	2	0.98	199
17	Dept. of Information Technology, Govt of India	1	0.49	200
18	Ministry of Tribal Affairs, Govt of India	1	0.49	201
19	UNICEF, Patna	1	0.49	202
20	Rajeev Gandhi National Drinking Water Mission, Govt of India	1	0.49	203
21	Indian National Science Academy (INSA), Bangalore	1	0.49	204

5.6 Work Force Participation in GAP

Resultant data shows that, a total 383 personnel at different levels were involved in the project. The level of contribution are scaled as per designation of scientists, technical personnel, research scholar, and their responsibility associated with projects are categorized as responsibilities like, Project Leader, co-project leader and Member. The scales of different levels are made according to designation as mentioned below:

- Level-I Scientist – B, C, E-1; (Lower Level)
- Level-II Scientist – E-II; (Middle Level)
- Level-III Scientist – F, G. (Higher Level)
- Technical Personnel – (Technical Grade III/1--7)
- Research Scholars – (JRF, SRF, QHF, Project Assistant)

The data pertaining to human resources have been based on the above statements as presented in Table 2 for analysis and interpretation. The performance of junior level scientists was outstanding and can be placed at rank 1 with participation in 45.69% of the total 383 work force. A total of 175 junior level scientists were engaged in handling 94 projects at various capacities – Project leader (94), Co-project leader (42), and Members (39). The senior level scientists registered second rank with participation in 55 projects, contributed at different capacities- Project Leader (55), Co-project leader (18), and as Member (30), over all 26.89% of human resource meet from this group, where as Middle level scientists were found involved in 49 projects with different responsibilities such as project leader (49), Co-project leader (17) and Member (9) respectively. These groups in all constitute 19% of the total work force and may be placed in third rank. The technical personnel and research scholars also have extended their valuable contribution in completion of R&D as team member. Fig. 8 depict the overall involvement of human resource in Grant-in- aids Projects.

Table 2: Involvement of work force in projects

Designation	Level of Contributions				Cumulative	%
	Project Leader	Co-Project Leader	Member	Total		
Junior Level	94	42	39	175	175	45.69
Middle Level	49	17	9	75	250	19.58
Senior Level	55	18	30	103	353	26.89
Technical	--	--	22	22	375	5.74
Research Scholar	--	--	8	8	383	2.08
Total	**198**	**77**	**108**	**383**	**--**	**100.00**

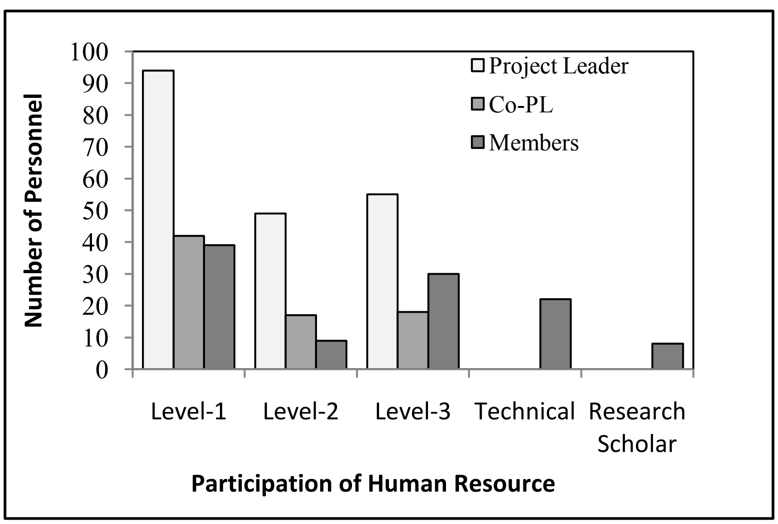

Fig. 8: Work force participation in grant-in-aid projects during 1995-2010

5.7 R&D Output through Projects

The R&D output of GAP projects have been evaluated through various parameters like new processes developed, technology transferred, patents, copyright filed, awards won through the performance of projects, contribution to academia, etc.

5.7.1 Types/Categories of Research Related to Projects

R&D output is determined through feedback received from project leader, shown in the questionnaire. The data were analyzed based on the extent to which the projects meet their objectives. A total of 204 projects were analyzed and found that, 59% of the total projects were under taken on basic research; 25% projects were related to applied research, where as industrial research could share only 10 % of the total projects. Figure 9 highlights percentage of all categories of research.

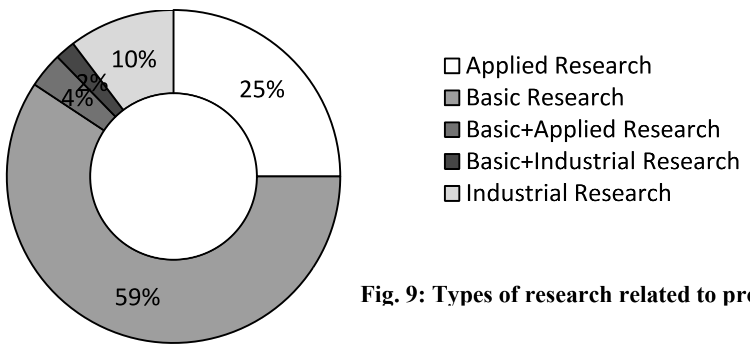

Fig. 9: Types of research related to projects

5.7.1.1 Scales of projects

A maximum of 81% projects are executed under laboratory scale, followed by pilot scale constituting 11%, where as field and a combination of lab + pilot scale share 6% and 2% respectively. The overall scales of R&D projects are depicted in Fig.10. The infrastructure and facilities have been developed through projects fund according to the requirements of specific projects. However, already available equipment, experimental set up and others facilities also helped in execution of projects at all scales.

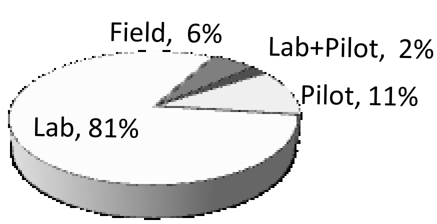

Fig. 10: Scales of Projects

5.7.2 Process Developed and Transferred

The technological output of each of the projects has been determined according to projects belong to different types of research. The output of the projects reflect that the basic research has produced 22 processes and 1 technology could be transferred with earning of royalty, and 12 projects were in pipeline for transfer to a third party. These categories of projects performed extremely well in comparison to other, whereas the projects related to applied research have explored 21 processes and 1 technology was transferred, and two are awaiting transfer. The projects related to Industrial research have invented 8 technologies and all are under negotiation stage for transfer. The overall performances of GAP are charted in Table 3.

Table 3: R&D output in the area of technology developed and transfer

Types of Research	Technology Output				Others*
	Status				
	Process Developed	Technology Transferred	Under Negotiation	Not Explored	
Basic Research	22	1	12	-	
Applied Research	21	1	2	15	7
Basic+Applied Research	4	-	4	-	-
Basic + Industry	2	-	-	-	-
Industrial Research	8	-	5	2	-
Total	**57**	**2**	**23**	**17**	**-**

Others Database development*

5.7.3 Technology Reported

During 1995-2010, a total of 35 patents and 14 copyrights were filed. 12 patents (34%) were filed under Industrial research and 4 copyrights (16.66%) were also reported, followed by projects related to basic research registered 11 patents which constitute 31% and 10 copyrights were reported. The projects related to applied research secured third rank with 6 patents sharing 13.33%. The overall performance can be seen in Table 4, which encompasses 16 years history of technology reported through different Grant-in-Aid projects sponsored by various agencies viz- Government, Private, Public Sectors, Private Sectors. The maximum patent filed under industrial research indicates that the application-oriented research related projects had shown the best performance among all categories of research.

Table 4: Technology reported

Types of Research	Technology Reported					
	Patent filed	Cumulative	%	Copyright	Cumulative	%
Basic Research	11	11	31.42	10	10	41.66
Applied Research	6	16	17.14	-	-	-
Basic+Applied Research	5	21	14.28	-	-	-
Basic + Industrial Research	2	23	5.71	-	-	-
Industrial Research	12	35	34.28	4	14	16.66

5.7.4 Collaboration of R&D Output

The importance of any project can be judged by its sustainability in future through link up with other projects; hence, the same parameter has been used to measure effectivity of projects. The findings clearly depict that 16 projects have been collaborated under basic research with Industries (1project), followed by Academia (7 projects), R&D Institutions/ Organizations (8 projects) and 2 projects are in pipeline for collaboration. Industrial research managed to collaborate with 14 projects concerned to different sectors – like Industries (3 projects), Academia (7 projects), R&D (4 projects) and 5 projects are waiting for collaboration. The overall collaboration scenario are given in Table 5.The findings indicate that basic and industrial research related projects have performed well and collaborated with other projects.

Table 5: Collaborations of R&D

Type of Research	Collaboration of R&D				
	Industry	Academia	R&D	Total	Under Negotiation
Basic Research	1	7	8	16	2
Applied Research	1	-	-	1	1
Basic+Applied Research	-	-	1	1	-
Industrial Research	3	7	4	14	5

5.7.5 Academic Contributions

During 1995-2010, a total of 58 students have been benefited through projects, which comprise different levels of education, ranging from Bachelors of Technology to Post Doctoral Fellowship in the area of metallurgy, materials science, and allied subjects. Table 6 shows a status of contribution towards curricular programme under GAP at NML for last sixteen years. The projects under basic research helped 36 students to complete their projects and dissertations exercise attached to course work at different levels viz, 14 B.Tech, 5 M.Tech, 15 PhD, and 2 PDF, whereas the Industrial Research related projects has helped 9 students out of them 7 students were of M.Tech level and 2 are PhD level completed their reports and dissertation based on the subject area of projects. The Basic+Applied Research also helped 6 students. Fig. 11 depicts the status of the overall impact of GAP towards academic contributions.

Table 6: Contributions towards public goods

Type of Research	Contributions towards Academia				Total
	B.Tech	M.Tech	PhD	PDF	
Basic Research	14	5	15	2	36
Applied Research	-	2	1	2	5
Basic+Applied Research	-	4	2	-	6
Basic+ Industry	-	-	2	-	2
Industrial Research	-	7	2	-	9
Total	**14**	**18**	**22**	**4**	**58**

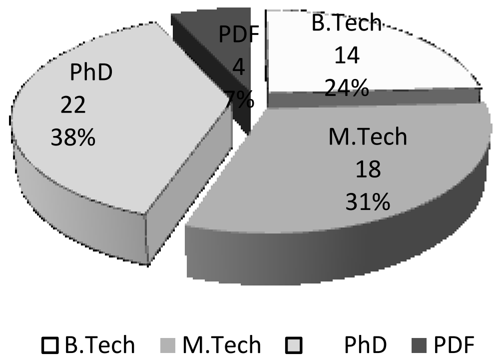

Fig. 11: Impact of projects towards public good

5.7.6 Awards/Honors won under GAP

Awards are reliable parameter for evaluation of R&D projects. During 1995-2010, a total of 16 awards of different categories were won based on performance of research findings. However, awards may or may not be considered for the overall performance of project. The case study highlights that the projects under basic level of research won maximum numbers of awards that includes 5 National, 3 best papers, 1 poster and 2 local awards, where as the projects related to Industrial research won 2 National awards only, and Basic+ Applied Research categories bagged only one National award. The overall performance of projects belongs to different level of research as shown in Table 7.

Table 7: Awards / honors won under GAP

Level of Research	Awards/Honors won by GAP			
	National	Best Paper	Poster Awards	Local (NML)*
Basic Research	5	3	1	2
Applied Research	-	-	-	-
Basic+Applied Research	1	-	-	-
Industrial Research	2	-	-	2
Total	**8**	**3**	**1**	**4**

Local (NML) - Yearly provided by National Metallurgical Laboratory*

5.8 Publications Output

Every scientific work is directed at acquiring new collective knowledge and understanding. Thus, one important characteristic of science is that new results have to be communicated to others, so that they can be tested and used by its intended audience. This is true for all fields of science, whether it is curiosity-driven or application oriented, basic science or technology. Basic science, whether it is curiosity-driven or application oriented, basic science or technology. Basic research is a powerful engine to drive the development of high technologies by providing scientific discoveries and technological innovations. There are, however, different approaches to achieve the main goal and accordingly, different ways to communicate new results. Publications in referred international peer reviewed journals are the primary and generally accepted means to make new results available to the scientific community in several branches of science, but this is by no means true for all disciplines and specialties [43]. Fundamental new knowledge is produced in both curiosity-driven and application-oriented research. In the former type of research, results will certainly find their way into the international journal literature. In the latter, however, the generation of new knowledge is combined with the integration of knowledge from several fields in order to win new insights. In those areas, even very fundamental and new knowledge may make available primarily in a new instrument (or a machine, a construction, a process, software, etc.). The same results may be laid down in patents, reported at conferences and finally, could find its' space in reputed journals.

5.8.1 Papers published under GAP during 1995-2010

During 1995-2010, 608 research papers have been reported under Grant- in- Aids projects in the areas of metallurgy, materials science, and allied subjects. Year- wise distribution of papers appeared in various formats are depicted in Table 8 for analysis and interpretation.

5.8.1.1 Analysis and Interpretation

According to overall performance during 1995-2010, the year 2006 is in first position with a total 75 papers (12%) contributed for the laboratory through GAP. The papers were further analyzed according to channel of their communication and found, 40 papers were reported in SCI, followed by 3 in Non-SCI, 21 national, 9 in international conference proceedings and only 2 papers appeared as book chapters. Similarly, the year 2009 contributed a total of 67 papers (11%), which includes 32 SCI and 7 Non-SCI; whereas national and international conference proceedings shared 9 and 18 papers respectively while Book Chapter accounted only 1 paper, which is highly insignificant. The year 2005, on the other hand, occupied third rank with share of 63 papers (10%), scattered in different formats such as, 26 SCI, 3 Non-SCI, 25 national and 9 international conference proceedings respectively. The overall performances in the area of publications contributed under GAP are given in Table 8. Figure 12 shows the trends of publications. The said figure has also unmasked a remarkable feature of an increasing trend of such publications in SCI format that seems to be quite significant.

Table 8: Year-wise distribution of papers based on projects findings during 1995-2010

Year(s)	Journal		Proceedings		Book Chapters	Total	%
	SCI	Non-SCI	National	International			
1995	1	3	3	-	-	7	1.151
1996	2	3	3	-	-	8	1.315
1997	1	1	9	3	-	14	2.302

Year(s)	Journal		Proceedings		Book Chapters	Total	%
	SCI	Non-SCI	National	International			
1998	5	3	5	5	-	18	2.960
1999	8	6	5	7	-	26	4.276
2000	5	2	5	1	1	14	2.302
2001	13	3	4	3	-	23	3.782
2002	16	10	8	3	-	37	6.085
2003	19	7	2	9	2	39	6.414
2004	27	13	9	3	-	52	8.552
2005	26	3	25	9	-	63	10.361
2006	40	3	21	9	2	75	12.335
2007	39	5	7	11	-	62	10.197
2008	37	4	9	9	1	60	9.868
2009	32	7	9	18	1	67	11.019
2010	33	3	2	3	2	43	7.072
Total	**304**	**76**	**126**	**93**	**9**	**08**	**100.00**

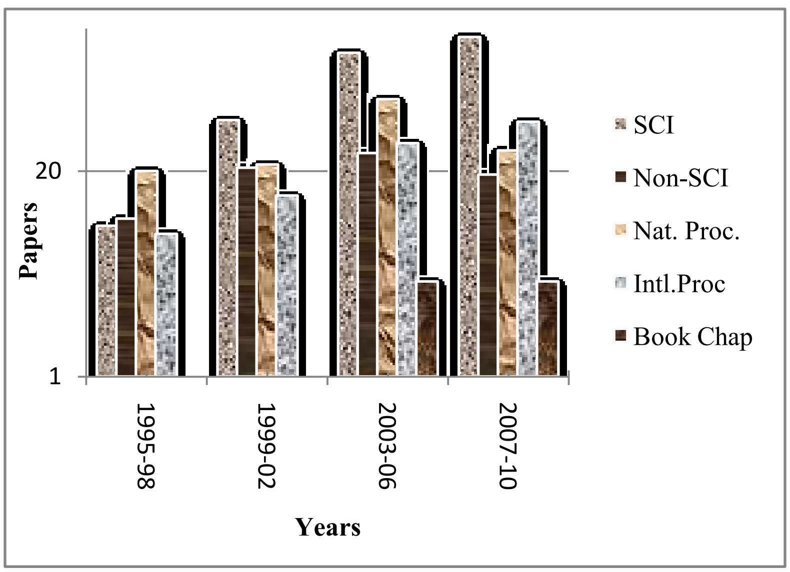

Fig. 12: Publications under various channels

5.8.2 Quality of Research under Different Scale

The assessment of research output has progressively developed as an important issue for the scientific research community, and citation analysis has become a commonly used technique in this field. Although not originally intended for this purpose, citation analysis and the impact factor are the important tools frequently used to evaluate the work of individual researchers, to determine faculty rank, performance of projects and their sustainability in future. Hence, by considering the importance of citations and impact factor, the same has been applied. Data collected pertaining to quality of citations and Impact factors are classified, organized, analyzed, and presented in table 9 for further analysis and interpretation. The findings show that, the projects under basic research contributed 226 research papers with 845 citations, and shared 64.50% of the total 1310 citations. The Average Impact Factor of journals was 1.552, followed by projects under Applied research which published 31 SCI papers and received 183 citations, which constitute 13.96%, the IF of the journals remains 2.412, registering 1st rank, but in publications, placed in second rank. The combination of Basic and Applied research related projects, placed in third rank with 17 papers credited with 116 citations (8.85%) and the average IF of communicated journals were 1.765. This category of research according to IF may be placed in second rank. The overall performances of projects for citations and Impact Factors under various types of research are given in Table 9 and Fig. 13, which unmask the 16 years performance.

Table 9: Papers Published under different scale of project with citations & impact factor (only SCI papers)

Scale of Research	Papers (SCI)	Cumulative	%	Citations	Cumulative	%	Impact Factors (Average)
Basic Research	226	226	74.34	845	845	64.50	1.552
Applied Research	31	257	10.19	183	1028	13.96	2.412
Basic+Applied	17	274	5.59	116	1144	8.85	1.765
Basic+ Industrial	9	283	2.96	57	1201	4.35	0.310
Industrial Research	21	304	6.90	109	1310	8.32	1.323
Total	**304**	-	**100.00**	**1310**	-	-	-

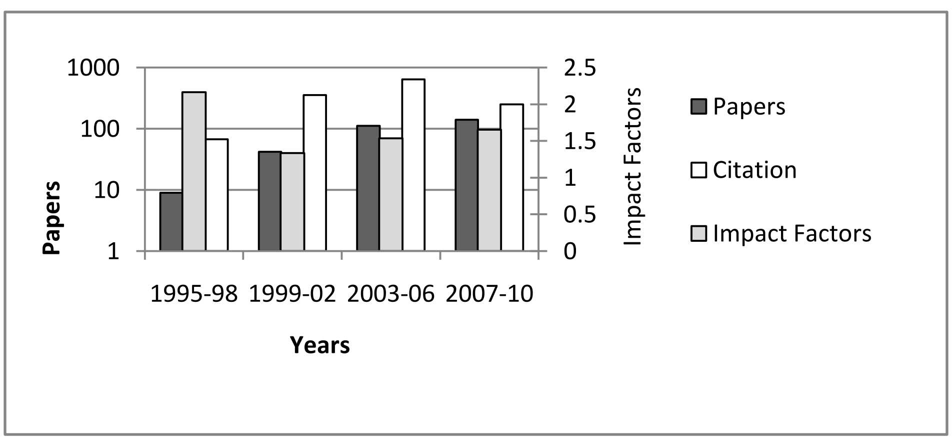

Fig. 13:

5.8.3 Highly Cited Papers of Gap during 1995-2010

Highly *Cited Research* reveals the face of research - the people behind the accomplishments. Generally, citations to papers peak in the second, third, or fourth year after publication, but some papers continue to be cited for many years. A few papers can exhibit delayed recognition. The patterns can vary greatly depending on the type of paper, the field, and the nature of the findings reported. Papers reporting discoveries, for example, can rise quickly and then fall as the discovery is further elaborated in other articles. Papers reporting methods or techniques can gradually increase in citation frequency over several years as the methods diffuse throughout the community and prove their utility [44].

The potentiality and credibility of a researcher and his findings are often judged by the number of times; the paper(s) has/have been cited. The more a paper is cited, the greater would be its research value and impact as often construed. The resultant data pertaining to 15 highly cited papers are shown in Table 10 fewer than five broad categories along with the percentage of average citations a paper receives. Highly cited papers of the Chemistry Division of the Bhabha Atomic Research Centre were analysed by *Kademani et.al, 2007* [45]. The same model was employed for GAP publications of NML and findings of it are presented with 15 highly cited papers. Citation life cycles of the four highly cited papers have been given in table-10 with their bibliographic details (*Mishra et al 2010)* [46]

5.8.3.1 Analysis and Interpretation

The paper P1 has received 88 Citations during 2002-2010, out of which 4 were self-citations. The said paper has received citations after one year of its publication. The average Citations per year was 9.78. There were 25 journals Citing this papers. Diachronous self-citation rate was 4.54.

The paper P2 has received 44 Citations during 2000-2010, out of which, 7 were self-Citations. This paper has received citation after one year of its publication and continues to receive citations during the period under study. This paper was 7 times self –cited by the author. The average citation per year was 6.29. There were 14 Journals in all, which were citing this paper. Diachronous self-citation rate was 15.90.

The paper P3 has received 41 Citations during 2001 to 2010. This paper has received citations after 2 years of its publication and continues to receive citations during the period under study. This paper has been cited in 21 Journals and the average rate of citation per year was 4.10. Diachronous self-citation rate was 0.

The paper P4 has received 34 Citations during 2004-2010 out of which, 6 were self-Citations. This paper has received citation after one year of its publication and continues to receive citation during the period under study. The average citations per year were 4.86.

Table 10: Highly cited papers of GAP during 1995-2010 (as on 28.09.2010)

Paper/ Project	Bibliographic Details of Highly Cited papers	SC	CO	TC	CTY	DR	Average Citation
P1/ GAP:0006*	Chakravarty S, Dureja V, Bhattacharyya G, Maity S, Bhattacharjee S. Removal of arsenic from groundwater using low cost ferruginous manganese ore. Water Research, V.36 (3), pp 625-632 (2002).	4	84	88	1	4.54	9.78
P2/ GAP:0060	Murugananthan M, Raju GB, Prabhakar S. Separation of pollutants from tannery effluents by electroflotation Separation and Purification Technology, V.40 (1), pp 69-75 (2004).	7	37	44	1	15.90	6.29
P3/ GAP:0049	Jha MK, Kumar V, Singh RJ. Review of hydrometallurgical recovery of zinc from industrial wastes , Resources Conservation and Recycling V 33 (1) pp 1-22 (2001)	0	41	41	2	0	4.10
P4/ GAP:0060	Murugananthan A, Raju GB, Prabhakar S Removal of sulfide, sulfate and sulfite ions by electro coagulation. Journal of Hazardous Materials V 109 (1-3) pp 37-44 (2004)	6	28	34	1	17.64	4.86
P5/ GAP:0074	Krishnaveni K, Narayanan TSNS, Seshadri SK. Electroless Ni-B coatings: preparation and evaluation of hardness and wear resistance,Surface & Coatings Technology V 190 (1) pp 115-121 (2005)	4	22	26	3	15.38	3.86
P6/ GAP:0037	Pathak LC, Ray AK, Das S, Sivaramakrishnan CS, Ramachandrarao P. Carbothermal synthesis of nanocrystalline aluminum nitride powders , Journal of The American Ceramic Society V 82 (1) ,pp 257-260 (1999)	0	21	21	1	0	1.75
P7/ GAP:0018	Tripathy T, Bhagat RP, Singh RP.The flocculation performance of grafted sodium alginate and other polymeric flocculants in relation to iron ore slime suspension , European Polymer Journal V 37 (1) pp 125-130 (2001)	2	17	19	0	10.52	1.73

Paper/ Project	Bibliographic Details of Highly Cited papers	SC	CO	TC	CTY	DR	Average Citation
P8/ GAP:0057	Mishra SK, Das SK, Ray AK, Ramachandrarao P.Effect of Fe and Cr addition on the sintering behavior of ZrB2 produced by self-propagating high-temperature synthesis,Journal American Ceramic Society V 85 (11) pp 2846-2848 (2002)	0	19	19	3	0	211
P9/ GAP:0074	Narayanan TSNS, Krishnaveni K, Seshadri SK Electroless Ni-P/Ni-B duplex coatings: preparation and evaluation of microhardness, wear and corrosion resistance. Materials Chemistry & Physics V 82 (3) pp 771-779 (2003)	6	13	19	1	31.57	2.71
P10/ GAP:0068	Mandal S, Ray AK, Ray AK. Correlation between the mechanical properties and the microstructural behaviour of Al2O3-(Ag-Cu-Ti) brazed joints Materials Science & Engineering A-Structural Materials Properties Microstructure & Processing V 383 (2) pp 235-244 (2004)	7	12	19	4	36.84	2.71
P11/ GAP:0057	Khanra AK, Pathak LC, Mishra SK, Godkhindi MM. Effect of NaCl on the synthesis of TiB2 powder by a self-propagating high-temperature synthesis technique, Materials Letters, V 58 (5) pp 733-738 (2004)	9	9	18	1	50.00	2.57
P12/ GAP:0001	Jana RK, Singh DDN, Roy SK. Alcohol-Modified Hydrochloric Acid Leaching of Sea Nodules. Hydrometallurgy, V 38 (3) pp 289-298 (1995)	4	13	17	2	23.52	1.06
P13/ GAP:0049	Jha MK, Kumar V, Singh RJ.Solvent extraction of zinc from chloride solutions . Solvent Extraction & Ion Exchange V 20 (3) pp 389-405(2002)	4	13	17	2	23.52	1.89
P14/ GAP:0108	Mishra SK, Das S, Pathak LC. Defect structures in zirconium diboride powder prepared by self-propagating high-temperature synthesis Materials Science &	10	7	17	1	58.82	2.43

Paper/ Project	Bibliographic Details of Highly Cited papers	SC	CO	TC	CTY	DR	Average Citation
	Engineering "A"-Structural Materials Properties Microstructure & Processing. V. 364 (1-2)pp 249-255(2004)						
P15/ GAP:0034	Pathak LC, Mishra SK. A review on the synthesis of Y-Ba-Cu-oxide powder, Superconductor Science & Technology V. 18 (9) pp R67-R89 (2005)	0	16	16	1	0	2.67

Source: www.isiknowledge.com visited on 28.09.2010

SC-Self Citation, CO- Citation by others, TC-Total Citation, CTY-Citation Lag, DR-Diachronous ratio (determined by applying following formula)

GAP- Grant-in-Aid Project followed by code is a project number.*

6 CONCLUSION

During 1995-2010, CSIR-National Metallurgical Laboratory received 204 Grant-in-Aid projects, sponsored by various agencies.Largest number of projects were assigned by the Department of Science and Technology,Government of India.The duration of the projects ranged from 6 months to 5 years.The value of projects were estimated around Rupees 55 Crore. About 97% projects were accomplished in scheduled time. A maximum 22 projects received in 2003, where as maximum revenue through projects were generated in 2008. The R&D output reflects that 55 process were developed and only one technology could be transferred.However 21 technologies are under negotiation for transfer to different parties.

During the tennure of projects, 40 patents and 14 copyrights were filed based on projects findings. About 58 students from various reputed academic institutions were benefited by the above projects. The project(s) related to basic level of research won the maximum number of awards. During 1995-2010, a total 608 papers were reported, based on projects findings. The trends of publications during 16 years, shows that SCI papers are in increasing trends and reflects a healthy sign as performance indicators of the sponsored projects. The projects under basic research contributed a maximum 226 papers with 845 citations, shared 64.50% of the total 1310 citations. The Average Impact Factor of papers was 1.552. The highly cited papers were published in the R&D area of Water Quality-Assessment, which received 88 Citations, other highly cited papers fall in the domain of Corrosion protection and prevention, Waste Management and Utilization and Materials Science and Technology.

$$\text{Diachronous self Citation Rate} = \frac{\text{Self - Citation to an article in SCI Database}}{\text{Total number of Citations Received to an Article in SCI Database}} \times 100$$

The management of the Institute wants to see the ranking of the projects once in every month. Although the proposed method is developed by experience, it is a generic model that can be adapted or extended for ranking projects in any organization. The criteria/sub- criteria used in this case study are specific to the Institute; parameters for evaluating project performance and their priorities will vary in each organization. However, the proposed approach can be implemented in any organization by making the necessary changes in the criteria/sub-criteria and the pair- wise comparison judgments. As a future study, this approach can be extended as per deliverables of the projects output.

7 ACKNOWLEDGEMENT

The authors are grateful to Dr. Srinivasan Srikanth, Director, CSIR-National Metallurgical Laboratory, Jamshedpur, for valuable suggestion and guidance for selecting parameters to evaluate projects. We are also grateful to the entire Project leader for responding with feedback and spent valuable time for the execution of the present assignment for the organization.

8 REFERENCES

1. http://bdmserver/e107plugins/content/content.php (accessed on 2.12.2011)
2. UNSECO.The state of Science and technology in the world 1996-1997, 2001, Available at http://www. uis.unesco.org. php? ID2+DO_PRINTPAGE.
3. Ranga, L.M.; Koenraad, D. and Nick Von, T. (2003) Entrepreneurial universities and the dynamics of academic knowledge production: A case study of basic vs. applied research in Belgium. *Scientometrics,* 58(2): 301-320.
4. Chung, S. and Grupp, H. (1990) R&D policies in Germany and their evaluation: R&D promotion policies and evaluation approaches. *Journal of Science and Technology Policy*, 2(1-2): 141-167.
5. Geisler, E. (1994) Key output indicators in performance evaluation of research and development organization. *Technological Forecasting and Social Change,* 47(2): 189-203.
6. Meyer-Krahmer, F. (1995) Technology Policy Evaluation in Germany. *International Journal of Technology Management,* 10(4-6): 601-621.
7. Ran, Anthony F.J. (2000) Socioeconomic impact of R&D: R&D evaluation at the beginning of the new century. *Research Evaluation,* 8(2): 81-86.
8. Kostoff, R.N. (1994) Quantitative/qualitative federal research impact evaluation practices. *Technological Forecasting and Social Change*, 45(2): 189-205.
9. Jenkins, B. (1993) Policy analysis: models and approaches In H.Michael (editor).the Policy Process: A Reader (Harvester Wheatsheaf, London); p34-44.
10. Jiancheng, G. and Nan, M.A. (2009) Structural equation model with PLS path modeling for an integrated system of publicly funded basic research. *Scientometrics,* 81(3): 683–698.
11. Wayne, G. and Barsky, N.P. (1994) Utilizing the balanced scorecard for R&D performance measurement. *R&D Management,* 34(3): 229-238.
12. Randle, K. (1997) Rewarding failure: operating a performance-related pay system in phararmaceutical research. *Personnel Review,* 26(3): 187-200.
13. Cameron, K. (1986) A study of organizational effectiveness and its predictors. *Management Science*, 32(1): 87-112.
14. Connolly, T; Conlon, E.J and Deutsch, S.J. (1980) Organizational effectiveness: a multiple constituency approach. *Academy of Management Review*. 5: 211-217.

15. Martin, B.R. and Irvine, J. (1983) Assessing basic research: some partial indicators of scientific progress in radio astronomy. *Research Policy*, 12(2): 61-90.
16. Oppenheim, C. (1997) The Correlation between Citation counts and the 1992 Research Assessment Exercise rating for British Research in Genetics, Anatomy and Archeology. *Journal of Documentation*. 53(5): 477-487.
17. Oppenheim, C. and Norris, M. (2003) Citation counts and the research assessment exercise V: archaeology and the 2001 RAE. *Journal of Documentation*, 56(6): 709-730.
18. Whitley, R. and Frost, P.A. (1971) The measurement of performance in research. *Human Relations*. 24(2): 161-78.
19. Grupp, H. (2000) Indicator – assisted evaluation of R&D programme: possibilities, state of the art and case studies. *Research Evaluation*, 8(2): 87-99.
20. Mela, G.S.; Martinoli, C and Poggi, E.; et. al. (2003) Radiological research in Europe: a Bibliometric study. *European Radiology*, 13(4): 657-662.
21. Lee, C.K.. (2003) A scientometric study of the research performance of the Institute of Molecular and Cell Biology in Singapore. *Scientometrics*. 56(1): 95-110.
22. Lee, M; Son, B. and Om, K.. (1996) Evaluation of national R&D projects in Korea. *Research Policy,* 25(5): 805–818.
23. Brown, W. B. and Gobeli, D. (1992) Observations on the measurement of R&D productivity: A case study. *IEEE Transaction Engineering Management*, 39(4): 325–331.
24. Chiesa, V. and Masella, C. (1996) Searching for an effective measure of R&D performance. *Management Decision*, 34(7): 49–57.
25. Hauser, J. R. and Zettelmeyer, F. (1997) Metrics to evaluate R, D, & E. *Research Technology Management*, 40(4): 32–38.
26. Kerssens-van Drongelen, I. C. and Cook, A. (1997) Design principles for the development of measurement systems for R&D processes. *R&D Management,* 27(4): 345–357.
27. Poh, K.L; Ang, B.W. and Bai, F. (2002) A comparative analysis of R&D project evaluation methods. *R&D Management*, 31(1): 63-75.
28. Bitman, W.R. and Sharif, N. (2008) A conceptual framework for ranking R&D projects. *IEEE Transaction Engineering Management*, 55(2): 267–278.
29. De Bandt, J. (1995) Research and innovation: evaluation problems and procedures at different levels. *International Journal of Technology Management*, 10(4-6): 365-377.
30. Daughton, J.M. (1997) Magnetic tunneling applied to memory. *Journal of Applied Physics,* 81(8): 3758–3763.
31. Rangarao, B.V. (1967) Scientific Research in India: An analysis of publication. *Journal of Scientific & Industrial Research,* 26: 166-167.
32. Roy, S; Nagpaul, P.S. and Pratap, K.J.M. (2003) Developing a model to measure the effectiveness of research units. *International Journal of Operations & Production Management,* 23(12): 1514-1531.
33. Vittorio, C.; et al. (2009) Performance measurement in R&D: exploring the interplay between measurement objectives, dimensions of performance and contextual factors. *R&D Management*. 39(5): 487-519.
34. Werner, B.M. and Souder, W.E. (2004) Measuring R&D performance – state-of-the-art. *Research. Technology Management,* 40(2): 34-42
35. Stahl, M.J. and Steger J.A. (1977) Improving R&D Productivity-Measuring Innovation and Productivity: A Peer Rating Approach. *International Journal of Research management*, 20(1): 35-38.
36. May, R.M. (1997) The scientific wealth of nation. *Science*, 275(5301): 793-796.
37. Braun, T. and Schubert, A. (2003) A quantitative view on the coming of age of interdisciplinarity in the science. *Scientometrics*, 58(1): 183–189.

38. Daigle, R.J. and Arnold, V. (2000) An analysis of the research productivity of AIS faculty. *International journal of Accounting Information System*, 1(2): 106-122.
39. Guan, Jiancheng and He, Ying. (2005) Comparison and evaluation of domestic and international outputs in information science and technology research of China. *Scientometrics*, 65(2): 215–244.
40. Brown, M.G. and Svenson, R. (1998) Measuring R&D productivity. *Research Technology Management*, 1-30. http://www.zigonperf.com/resources/pmnews/measure_ productivity.htm (accessed 10 October 2011).
41. Ojanen, V. and Vuola, O. (2003) Categorizing the Measures and Evaluation Methods of R&D Performance-A State-of-the-art Review on R&D Performance Analysis. *Telecom Business Research Centre Lappeenranta, Working papers* -16,Lappeenranta University of Technology, 1-22.
42. http://metalsabout.com/library/bldef-Metallurgy.htm (accessedon 7.10.2010).
43. Jansz, M.C.N. (2000) Some thoughts on the interaction between scientometrics and science and technology policy. *Scientometrics*, .47(2): 253-264.
44. http://sciencewatch.com/about/met/ (accessed on 2.12.2011)
45. Kademani, B.S.; et al. (2007) Research and citation impact of publications by the Chemistry Division of Bhabha Atomic Research Centre. *Scientometrics*, 71(1): 25-27.
46. Mishra, P.N.; Panda, K.C. and Goswami, N.G. (2010) Citation analysis and research impact of National Metallurgical Laboratory, India. *Malaysian Journal of Library & Information Science*, 15(1): 91-113.